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A FUTURE DIRECTION IN PILOT TRAINING

ABSTRACT

This paper describes a concept to promote aviation safety via improved training that builds upon the increasing use of data analyses for performance assessments, including the global Flight Operations Quality Assurance (FOQA) programs. The idea is to objectively analyze flight and simulator data in order to assess pilot performance and training effectiveness. Objective data can also be used to identify other issues (e.g., procedure problems, air traffic sequencing inefficiencies, aircraft maintenance needs, etc.) before they become problems, but the focus in this paper is on pilot training and performance. The foundation of the concept is to use existing metrics to detect and analyze pilot performance discrepancies by examining the situational context of such flight parameters as airspeed, altitude, heading, control positions, etc. Data analysis techniques draw from statistical data processing and quantitative models of human performance, and use existing commercial visualization and statistical software to evaluate single and multiple sets of flight data. The goal is to link operational performance discrepancies to training effectiveness so that training programs can be fine-tuned.

INTRODUCTION

Today's pilot training process is effectively *open loop* because pilots receive objective performance feedback relatively infrequently. Training effectiveness and operational performance are not directly determined from monitoring line operations either. Instead, verification is accomplished with simulator or flight "check rides" performed by check airmen who provide a subjective evaluation and are limited by their capacity to perceive and interpret all relevant data in real time.

Modern FOQA programs have precipitated an opportunity to revolutionize training. FOQA data analysis and visualization systems help *close the loop* between training and operations by enabling the objective analysis and presentation of integrated aircraft, aircrew, and airspace performance based on simulator and aircraft flight data. The analysis of simulator and flight data allows airlines to identify potential problems and to prescribe appropriate training <u>before</u> incidents or accidents occur. Also, due to the regular and objective monitoring of flight operations, it is possible to fine-tune and optimize operational procedures and training programs to improve their effectiveness and efficiency.

HISTORICAL PERSPECTIVE

Research has demonstrated that training people to operate complex systems, such as aircraft, is most effective when interactive simulation techniques, and high visual and functional fidelity are available. While multimedia techniques are a substantial improvement over traditional audiovisual and textbook approaches, most computer-based training (CBT) in use today does not support the full free-play interaction needed for exploratory learning or "what if" interactions that most effectively facilitate the learning of complex tasks. Full fidelity simulators are too expensive to use for basic skills training; most CBT does not have sufficient functional or visual fidelity for complex flight tasks; and, neither technology is designed to easily utilize flight data as a "reality check" on training effectiveness.

Traditionally, flight data are used for routine aircraft and engine performance monitoring, and when an accident or incident has occurred. FOQA initiatives, such as British Air's BASIS project, have made it possible to collect flight data and use these data to proactively assess aircraft and aircrew performance for the purpose of optimizing operational effectiveness and improving safety. Other programs (e.g., APMS in the U.S., and MAXVAL in Europe) are building upon FOQA's progress and will enable the statistical analyses of flight data. All of these programs advocate using flight data analyses to identify problems before incidents or accidents occur.

HOW TO CLOSE THE LOOP

One way to use flight data is to provide feedback of the information gleaned from analyses to line pilots via training programs aimed at enhancing safety and improving operational efficiencies. The question then becomes: How will the aviation community know that training will be, or has been, effective? One concept is to design and develop methods to use flight data to objectively measure training effectiveness.

To develop methods for objectively measuring training effectiveness, two existing technologies can be used in an innovative combination: (1) Flight data visualization products, and (2) Knowledge-based systems that detect procedural discrepancies and link them to training objectives. Combining these two technologies will help determine pilot training effectiveness via a feedback loop that specifies any re-training needed and that further identifies which training is most effective from the start. Each technology is further described below.

1. *Flight Data Visualization*

Several leading edge companies have developed high fidelity, real-time aircraft and flight simulator data visualization, analysis and debriefing systems. These systems enable the quick and easy creation of interactive, 3D graphical representations of real or simulated aircraft flights from any data source including flight data recorder (FDR) quick access recorder (QAR), ATC radar, real-time wireless telemetry, and simulators.

Training applications include post-simulation debriefings, airport familiarization, instructor training and standardization, SOP (standard operating procedure) reinforcement, part-task simulation, simulator certification, and other novel applications just now being discovered by users as these systems gain wider acceptance.

One of the best justifications for using a flight data visualization tool is a quote from a U.S. Naval Training System Center researcher's web site: "Insufficient attention has been paid to how to provide the aviator with training on the skills and knowledge that will enable him/her to plan, execute, and evaluate...[flights]. Specifically, there has been a lack of focus on how to structure practice and feedback and on how to incorporate debriefing capabilities in order to enhance training effectiveness." [1]
Data visualization products provide the

optimum setting for structured debriefings, by replaying simulator session data. Currently, airlines use such products for FOQA data analyses; but as yet there is no *direct* link from identifying problems to tailoring initial or recurrent training. Using high-fidelity debriefing tools makes outcomes and processes very inspectable and enables instructors and trainees to review and critique flights, and to compare them with “ideal” flights. Good performance is reinforced, while bad performance can be quickly identified and methods for improvement discussed. Furthermore, embedded video, when available, provides a means to examine crew resource management (CRM) issues. Data visualization allows instructors and trainees to examine process details while visualizing the “big picture” outcomes.

Being able to quickly and easily examine flight and/or simulator data allows everyone involved to identify performance discrepancies and devise remediation strategies. The enhancement to visualization products that will enable automated discrepancy detection and the link to specific training methods and techniques is a knowledge-based training tool, described next.

2. Knowledge-Based Training Link

By using expert system concepts to identify aircrew procedure discrepancies, one can envision a training tool that also links discrepancies to reasons why those discrepancies occurred. Discrepancy detection begins with recognizing which procedures or processes the aircrew are using (or should be using) in a given situation. Once the procedure is recognized, there are context spaces within the procedure that “expect” the aircraft system states (e.g., airspeed, pitch, and configuration) to be within specific limits.

For example, one airline defines approach “gates” such that if the aircraft is not within expected airspeed, vertical speed, thrust, and configuration limits, then the approach is considered to be unstable and the pilots should execute a go-around. If the aircraft states are within the expected limits there are no problems. However, if one or more states are not within expected limits, then a discrepancy exists.

Using an expert system to detect these discrepancies is fairly straightforward, and discrepancies are recorded for later analysis (e.g., during simulator ride debriefing). Lastly, the training tool suggests a remedy and then recommends retraining to address any discrepancies. Figure 1 depicts the knowledge base architecture for this training tool.

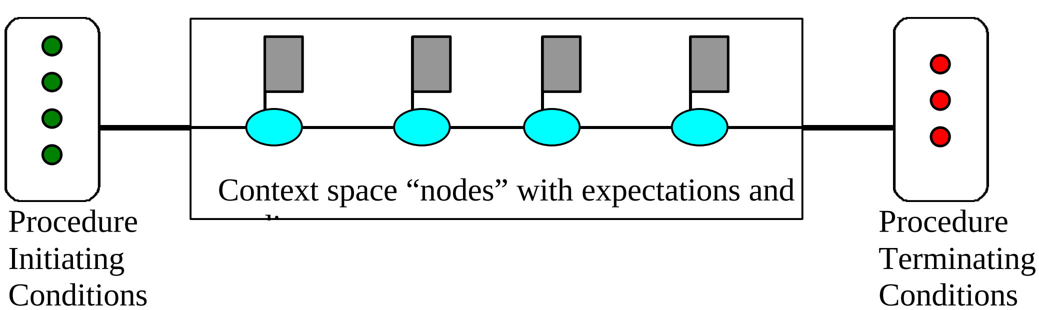

Figure 1. Training Tool Knowledge Base Architecture

Line-oriented flight training (LOFT) typically involves exposure to various situations so that trainees can recognize similar situations in the real world and apply the appropriate learned procedures and processes to achieve acceptable results. An innovative training tool, whose foundation is a detailed task analysis database, measures performance in order to understand LOFT deficiencies. It then correlates training strategies, methods, and styles to revenue flight and LOFT performance, thus helping airline training managers determine how best to invest their training resources. This concept of enhancing flight and simulator data visualization products with a knowledge-based training tool will enable instructors and analysts to focus on the performance aspects of a flight and to identify deficiencies that affect safety and efficiency. More to the point, such an innovation enables instructors to trace any discrepancies to specific training objectives and lessons, as diagrammed in Figure 2. And, it helps validate SOPs. To be complete, this tool also needs a pedagogical foundation to determine the best remediation strategies.

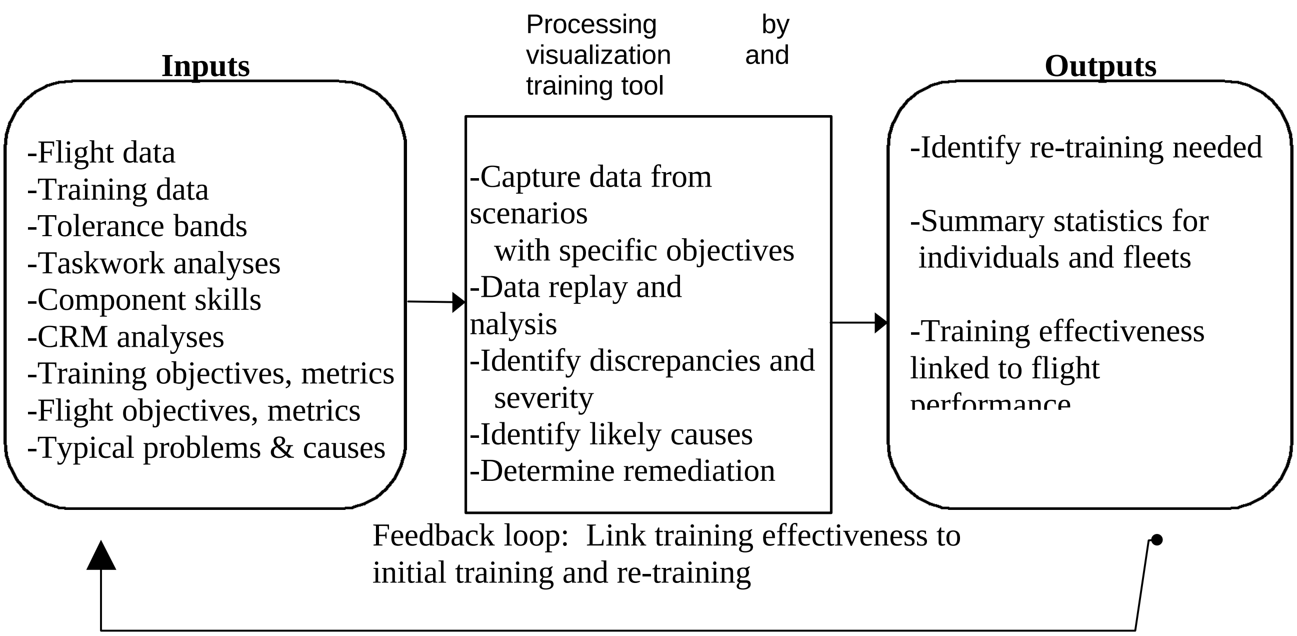

Figure 2. Preliminary Training System Model

OPEN LOOP TO CLOSED LOOP

The current methods used for pilot training result in an "open loop" system that has potential instabilities (to use control system theory jargon). The main reason for instability is that structured feedback from operational flights occurs rarely – usually only during annual or semi-annual check rides. The proposed method enables daily objective feedback that transforms an open loop, unstable system into a closed loop, stable system, which is inherently more controllable and manageable.

Besides the obvious control system analogy, it makes sense to take advantage of the available data to improve operations and enhance safety, which of course is why FOQA programs are gaining in popularity. But once the data are collected and analyzed, any ensuing procedural changes must be determined and tested. New or modified procedures must also be communicated to line pilots and, at least occasionally, trained in the simulator. Furthermore, collecting and analyzing simulator data enables a tighter feedback loop for even better control. Fortunately, data visualization and analysis systems work more effectively with simulator data than with flight data. These systems allow for objective data that are easily accessed.

Figure 3 illustrates this closed loop training-operations feedback cycle. The current process is depicted with solid arrows; the proposed process is depicted with dashed arrows and emphasizes the potential for <u>daily</u> feedback of operational issues to all interested participants in the aviation community.

the most thorough pre-briefings and debriefings possible, thus ensuring maximum training transfer. So the whole process is transformed from an open loop, reactive system into a closed loop, proactive system simply by collecting and analyzing

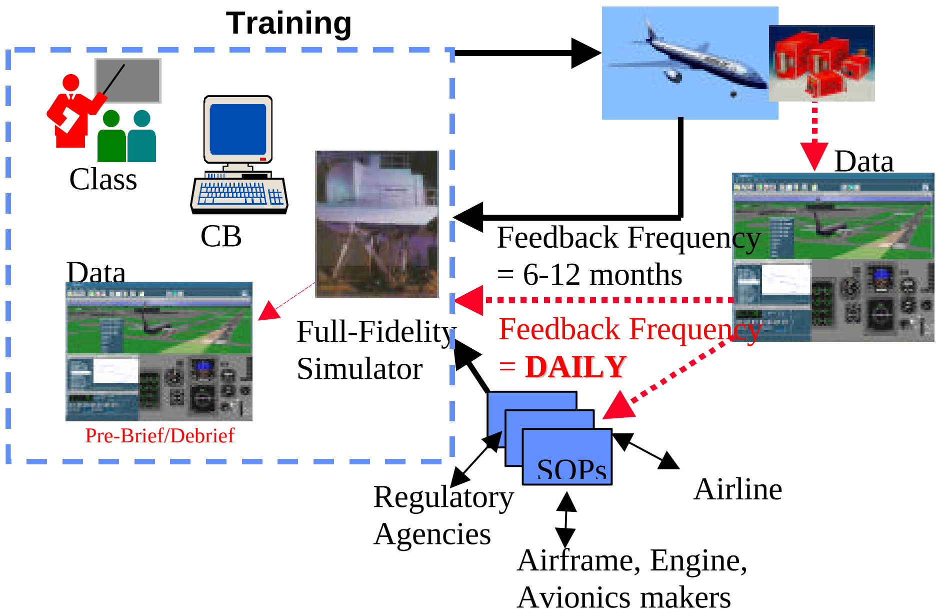

Figure 3. Training-Operations Cycle.

CONCLUSIONS

Linking flight and simulator session discrepancies to training and retraining is one key to this training effectiveness concept. Enhancing and combining existing leading-edge technologies will help link training to flight performance, including the feedback loop that will indicate the type of training to apply to improve performance when there are flight and training shortfalls. The feedback loop will also help to determine which training methods to apply in the first place so that both initial and recurrent training become as effective as possible. The innovation is to combine desktop, high fidelity, real-time data visualization products with knowledge-based training effectiveness tools in order to realize the goal of linking training to flight performance.

REFERENCES

[1] Bergondy, M. (1998). World-wide website: http://www.ntsc.navy.mil/bf/scitech/ appres2.htm.